



# FY 2019-20 Proposed Natural Gas Research Initiatives

Presented at the Stakeholders Workshop

California Energy Commission

January 24, 2019

9:00 am – 5:00 pm



# Workshop Agenda

Time	Topic
9:00 am	Introduction and Purpose – <b>Laurie ten Hope</b> <ul style="list-style-type: none"><li>• Strategic Planning Initiatives – <b>Kevin Uy</b></li><li>• Natural Gas Expansion – <b>Josh Croft &amp; Peter Chen</b></li></ul>
9:30 am	Staff Presentations on Proposed Natural Gas Research Initiatives: <ul style="list-style-type: none"><li>• Energy Efficiency – <b>Colin Corby &amp; Mikhail Haramati</b></li><li>• Renewable Energy and Advanced Generation – <b>Chuck Gentry</b></li><li>• Natural Gas Infrastructure Safety and Integrity – <b>Yahui Yang</b></li><li>• Energy-Related Environmental Research – <b>Guido Franco</b></li></ul>
11:00 am – Noon	Public Comments
	Next Steps – <b>Laurie ten Hope</b>



# Introduction

- For the Natural Gas FY 2018-19 budget, the Energy Commission R&D Program included a public vetting process with Stakeholders that included a public workshop.
- For the upcoming Natural Gas FY 2019-20 budget, Energy Commission R&D Program staff are holding this workshop seeking stakeholder comments on natural gas research initiatives.
- Specific “Questions for Stakeholders” will be posed during the workshop.

# General Approach

- Identify research gaps for research initiatives through:
  - Discussion with utilities, public stakeholders, state and federal governmental agencies, other Energy Commission programs, and
  - Roadmaps
  - Public meetings with industry and trade associations
  - Research ideas submitted by the public
- Research projects are selected through competitive solicitations
- Energy research priorities are guided by policy directives
- Need clearly identified benefits



# What's New for FY 2019-20?

- Request for Incremental Funding Expansion
- Implementation of CPUC Resolution G-3546
- New Initiatives Proposed
  - Long term decarbonization technology strategy
  - Natural gas infrastructure analysis
  - Expanded transportation alternatives
  - Initiate small grant program

# CPUC Guidance

In the draft CPUC Resolution G-3546, CPUC has given guidance to the Energy Commission to incorporate into the FY 2019-20 Natural Gas plan an...

*"explicit long-term strategy for the role of Gas R&D in the more aggressive statewide decarbonization goals set by Senate Bill 100 and Executive Order B-55-18. An area of potential exploration is how Gas R&D can be used to develop technologies to ease the transition away from natural gas towards less carbon intensive sources."*



# Expanding Natural Gas Program

The Energy Commission is proposing to incrementally expand the Natural Gas R&D budget. Due to priorities of achieving statewide carbon neutrality the Energy Commission will focus on the areas listed below in its first expansion request:

- Low-Carbon Natural Gas Small Grants Program
- Natural Gas-Related Transportation Research



# Commitment to Diversity

The Energy Commission adopted a formal resolution strengthening its commitment to diversity in our funding programs. We continue to encourage disadvantaged and underrepresented businesses and communities to engage in and benefit from our many programs.

To meet this commitment, Energy Commission staff conducts outreach efforts and activities to:

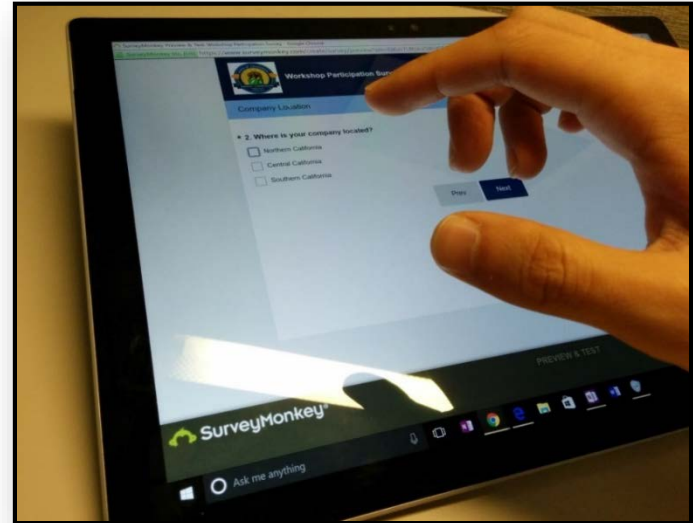
- Engage with disadvantaged and underrepresented groups throughout the state.
- Notify potential new applicants about the Energy Commission's funding opportunities.
- Assist applicants in understanding how to apply for funding from the Energy Commission's programs.
- Survey participants to chart progress in diversity outreach efforts.



# We Want to Hear From You!

## 1 Minute Survey

- The information supplied will be used for public reporting purposes to display anonymous overall attendance of diverse groups.
- Does your company identify as an underrepresented group?
- Where is your company located?
- How did you hear about the workshop?



# Stay Updated with Email

- The Energy Commission has an email listserv system to distribute timely information on various topics about Commission announcements, programs, funding opportunities, workshops, and more.
- Subscribe to the listserver of your choice by going to:  
[www.energy.ca.gov/listservers](http://www.energy.ca.gov/listservers)



## RESEARCH & DEVELOPMENT LISTS

- ☐ epic - Electric Program Investment Charge (EPIC) Program
- ☐ research - Energy RD&D / PIER program
- ☐ naturalgas - Natural Gas Research Program
- ☐ opportunity - RFPs, solicitations, contracts, funding announcements



# Connect with Us



# Find Partners Through LinkedIn



The Energy Commission has created a user-driven LinkedIn Networking group page to help potential applicants connect, collaborate, and partner on proposals for research funding opportunities. Participants may subscribe to the *"California Energy Commission Networking Hub"* by clicking on this link: [bit.ly/CalEnergyNetwork](https://bit.ly/CalEnergyNetwork)



# Budget and Priorities

- **Transparent Budget Process**
- **Clean Energy Transformation Priorities**
  - Infrastructure Safety
  - Climate Preparedness
  - System Decarbonization through Efficiency, Renewables and Lower Intensity Transportation
  - Equity
  - Ratepayer Benefits and California Focus
- **Support State Energy Policies and Governor's priorities**
- **Issues of Elevated Importance in 2018 Continue in 2019**
  - Senate Bill 100 and Executive Order B-55-18 on statewide decarbonization goals
  - AB 3232 Building Electrification
  - Governor's Executive Orders B-29-15 and B-30-15 on climate and drought
  - Greenhouse Gas Emission Reduction (AB 32 and SB 32)
  - CPUC Natural Gas Safety Policy Statement (July 2014)
  - Natural Gas: Leakage Abatement (SB 1371)
  - Governor's Aliso Canyon Gas Leak Proclamation
  - California Air Resources Board's (CARB) *Climate Change Scoping Plan Update*:
    - 1) Ensure safety of natural gas system 2) decrease fugitive methane emissions; and 3) reduce dependence on fossil fuel natural gas



# Policy Drivers

<i>FY 2019-20 Natural Gas Proposed Budget Plan</i>	<i>Research Areas</i>				
<i>Policy Drivers</i>	<i>Efficiency *</i>	<i>Renew- ables **</i>	<i>Safety and Integrity ***</i>	<i>Environ- mental ****</i>	<i>Trans- portation *****</i>
<b>Energy Action Plan:</b> Establishes goals to ensure adequate, reliable, and reasonably-priced natural gas supplies are achieved through policies, strategies, and actions that are cost-effective and environmentally sound for California's consumers and taxpayers.	X	X	X	X	X
<b>Integrated Energy Policy Report:</b> Biennial Report to Governor and Legislature on trends and issues concerning electricity and natural gas, transportation, energy efficiency, renewables, and public interest energy research	X	X	X	X	X
<b>Assembly Bill 32: Global Warming Solutions Act.</b> Requires GHG emission reduction of 15% below 1990 levels by 2020 for transition to a sustainable, low-carbon future while maintaining a robust economy.	X	X	X	X	X
<b>Senate Bill 32:</b> Requires California to reduce GHG emissions to 40% below 1990 levels by 2030.	X	X	X	X	X
<b>California's 2017 Climate Change Scoping Plan.</b> Establishes framework of action for California to meet 40 percent reduction in greenhouse gases by 2030 compared to 1990 levels. Builds off of programs established by AB 32.	X	X	X	X	X
<b>Senate Bill 1250:</b> Public Goods Utilities surcharge to support public interest R&D for energy efficiency and renewable, conservation activities.	X	X	X	X	X
<b>Public Resources Code 25620:</b> Directs state to undertake public interest energy RD&D projects that are not adequately provided by energy markets and to advance energy science or technologies of value to California ratepayers.	X	X	X	X	X
<b>Public Utilities Code Section 895:</b> Provides statutory authority for the Energy Commission to administer the natural gas funds.	X	X	X	X	X
<b>Executive Order B-30-15:</b> Set greenhouse gas reduction target of 40 percent below 1990 levels by 2030.	X	X		X	X
<b>Senate Bill 350: Clean Energy and Pollution Reduction Act of 2015.</b> Establishes annual targets to achieve 50% renewables and cumulative doubling of statewide energy efficiency savings by Jan. 1, 2030.	X	X			
<b>Energy Efficiency Buildings Standards (Title 24, Part 6).</b> Standards for energy and water efficiency requirements to reduce California's energy consumption.	X				

(\*Energy Efficiency Research, \*\*Renewable Energy and Advanced Generation, \*\*\*Infrastructure Safety and Integrity, \*\*\*\*Energy-Related Environmental Research, \*\*\*\*\*Natural Gas-Related Transportation Research)



# Policy Drivers (cont.)

FY 2019-20 Natural Gas Proposed Budget Plan		Research Areas				
Policy Drivers		Efficiency *	Renewables **	Safety and Integrity ***	Environmental ****	Transportation *****
<b>Appliance Energy Efficiency Standards (Title 20, Division 2, Chapter 4, Article 4, Sections 1601-1608 Appliance Efficiency Regulations):</b> Standards to reduce energy consumption and improve energy efficiency of residential and commercial appliances.		X				
<b>Assembly Bill 758:</b> Achieves greater energy savings in existing residential and nonresidential buildings.		X				
<b>Assembly Bill 531:</b> Discloses commercial building electric and natural gas use.		X				
<b>California Energy Efficiency Strategic Plan:</b> Zero Net Energy Buildings, transformation of HVAC industry, increase of NG use in on-site renewable energy and agricultural sectors.		X				
<b>Senate Bill X1-2 - Renewables Portfolio Standard:</b> Sets goals for 30 percent of retail sales from renewable energy resources by end of 2020.			X			
<b>Assembly Bill 1613 - Waste Heat and Carbon Emissions Reduction Act:</b> Requires electrical corporations to purchase excess electricity from CHP systems that comply with sizing, energy efficiency, and air pollution control requirements.			X			
<b>Governor Brown's Clean Energy Jobs Plan:</b> California to develop 12,000 MW of localized energy by 2020, make new buildings in California ZNE, and incentives for increased use of cogeneration by 6,500 MW by 2030.		X	X			
<b>Bioenergy Action Plan:</b> Sets goals for the production and use of electricity and fuels made from biomass.			X			
<b>SB1383: Short-Lived Climate Pollutant Reduction Strategy.</b> Recommends actions to reduce emissions of short-lived climate pollutants (SLCPs), including those from dairies, organics disposal, and WWTPs.			X		X	X
<b>High Energy Efficiency, Low Emissions Combustion, and Control Technology Development Program:</b> Addresses goal to improve environmental quality while meeting the wide-ranging demand for energy.		X	X		X	

(\*Energy Efficiency Research, \*\*Renewable Energy and Advanced Generation, \*\*\*Infrastructure Safety and Integrity, \*\*\*\*Energy-Related Environmental Research, \*\*\*\*\*Natural Gas-Related Transportation Research)





# Policy Drivers (cont.)

FY 2019-20 Natural Gas Proposed Budget Plan		Research Areas				
Policy Drivers		Efficiency *	Renew- ables **	Safety and Integrity ***	Environ- mental ****	Trans- portation *****
<b>Executive Order B-29-15:</b> Established actions to save water, prevent wasteful water use, streamline state's drought response, and invest in new technologies to make California more drought-resilient.				X	X	
<b>SB 1371 - Natural Gas Leakage Abatement:</b> To determine if existing practices are effective at reducing methane leaks, if alternative practices may be more effective with consideration to safety, reliability and affordability.				X		
<b>CPUC Natural Gas Safety Action Plan:</b> Ensures Californians receive safe, reliable utility service and infrastructure through safety compliance and enforcement, risk management/assessment, improved safety policy and safety promotion.				X		
<b>Senate Bill 887:</b> Natural Gas Storage Wells. Requires operators to notify the CPUC immediately of a leak of any size from gas storage well. Requires CPUC to notify public about reported leak that cannot be controlled within 48 hours.				X		
<b>Governor's Aliso Canyon Gas Leak Proclamation:</b> Directs further action to protect public health and safety, ensure accountability and strengthen oversight of gas storage facilities.				X		
<b>Senate Bill 380:</b> Order to determine feasibility of minimizing or eliminating use of the Aliso Canyon NG storage facility while still maintaining energy and electric reliability for the region.				X		
<b>Executive Order B-32-15:</b> Sustainable Freight Action Plan. Establishes the following: improve freight system efficiency by 25% by 2030, deploy 100k freight vehicles capable of zero-emission operation and maximize near-zero freight vehicles powered by renewables by 2030.						X
<b>2016 Mobile Source Strategy:</b> Reduce emissions from the heavy-duty vehicle sector with cleaner combustion engines, renewable fuels, and zero-emission technology to meet GHG reduction targets and attain federal health-based air quality standards for ozone and particulate matter.						X
<b>Low Carbon Fuels Standard (LCFS):</b> Reduce the full fuel-cycle, carbon intensity of transportation fuel pool in California through transition to cleaner/less-polluting fuels with a lower carbon footprint.						X
<b>AB 118 and AB 8: Alternative and Renewable Fuels and Vehicle Technology Program.</b> Increase deployment of vehicles and infrastructure for use of alternative fuels in transportation sector.						X

(\*Energy Efficiency Research, \*\*Renewable Energy and Advanced Generation, \*\*\*Infrastructure Safety and Integrity, \*\*\*\*Energy-Related Environmental Research, \*\*\*\*\*Natural Gas-Related Transportation Research)



# Strategic Planning Initiatives



Source: Energy+Environmental Economics (E3), Agreement no. PIR-16-011

Presenter: Kevin Uy

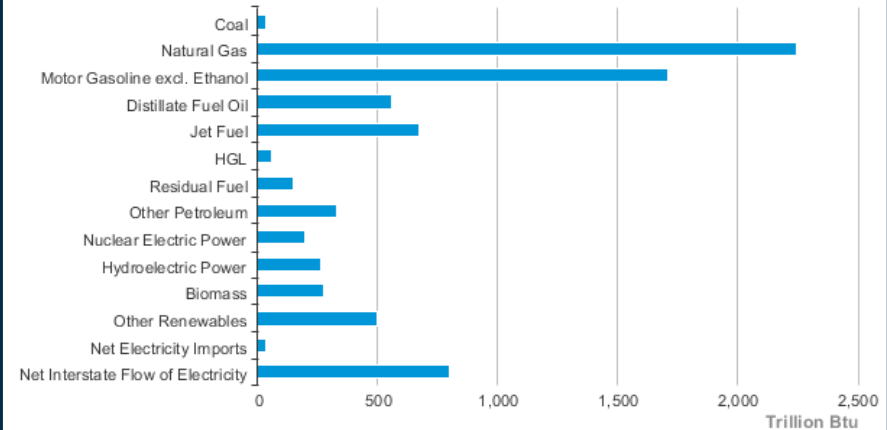
# FY 2019-20 Proposed Funding Initiatives

## Establishing a Long-Term Technological Development Strategy to Meet Aggressive Statewide Decarbonization Goals

### Issue:

- The California Public Utilities Commission, in its Draft Resolution G-3546, directs the Energy Commission to explore an explicit, long-term strategy for the role of Gas R&D in meeting aggressive state decarbonization goals.
- Natural gas is roughly one third of the primary energy use in California when accounting for all sectors.
- Natural gas use must decline dramatically in order to meet state decarbonization goals, however the pathway to achieve this is unclear.

California Energy Consumption Estimates, 2016





# FY 2019-20 Proposed Funding Initiatives

## Establishing a Long-Term Technological Development Strategy to Meet Aggressive Statewide Decarbonization Goals

### Background:

- In September 2018, Governor Brown set two of the most ambitious climate targets in history by signing SB 100 and issuing Executive Order B-55-18.
  - Senate Bill 100 (De León, Chapter 312, Statutes of 2018) requires that all retail sales of electricity in California be renewable or zero-carbon by 2045
  - Executive Order B-55-18 requires that the entire California economy achieve carbon neutrality by 2045.
- A primary goal of the Natural Gas Research and Development Program is to support research which advances state energy policy. The Energy Commission, in its research planning and implementation, strives to achieve this goal by responding to state directives and policy goals as they emerge.
- Previous technology development initiatives have focused on increasing efficiency and decreasing emissions while maintaining cost-effectiveness. While this R&D approach may work for achieving 2030 goals, no amount of efficiency or emissions improvements alone will achieve 2045 goals.
- The Energy Commission must explore the role of Natural Gas R&D in meeting these new landmark climate goals, including new energy pathways and the technologies to enable these pathways.



# FY 2019-20 Proposed Funding Initiatives

Establishing a Long-Term Technological Development Strategy to Meet Aggressive Statewide Decarbonization Goals

Background:

Below is a potential transition strategy in order to meet state goals:

	Near-Term	Mid-Term	Long-Term
Residential	Electrification		
Commercial	Electrification		
Industrial	Energy Efficiency & Emission Reduction	Low-Carbon Fuel	Electrification & Carbon Capture
Transportation (Light-Duty)	Low-Carbon Fuels & Electrification		
Transportation (Medium-Duty & Heavy-Duty)	Energy Efficiency & Emission Reduction	Low-Carbon Fuels	Electrification

However, the technologies required to fully achieve this transition do not exist currently.



# FY 2019-20 Proposed Funding Initiatives

## Establishing a Long-Term Technological Development Strategy to Meet Aggressive Statewide Decarbonization Goals

### Research Description:

- This research initiative aims to answer one key question: What technologies need to be developed in order to transition the state towards a carbon neutral energy system?
- This assessment will:
  - Examine each sector and determine how decarbonization could be achieved in the near-term (within 5 years), mid-term (5-10 years) or long-term (greater than 10 years).
  - Identify, by sector, technologies with the potential to significantly reduce or eliminate GHG emissions.
  - Establish a pathway for each sector to achieve decarbonization, including the technology research required to enable the pathway.
- The final result will be an explicit strategic plan for energy technology research in order to meet state carbon neutrality goals that provides priorities for electrification, renewables, and deep carbon reductions for remaining natural gas.



# FY 2019-20 Proposed Funding Initiatives

## Natural Gas Infrastructure Analysis and Strategic Pathway to a Low-Carbon Energy Issue:

- The California Public Utilities Commission, in its Draft Resolution G-3546, directs the Energy Commission to explore research related to building electrification given the prevalence of natural gas as a heat source and the extensive natural gas infrastructure in buildings.
- Electrification of buildings is a key strategy for the state to achieve its GHG reduction goals.
- The California Public Utilities Commission has expressed concern that building electrification could lead to significantly increased cost to ratepayers.\*
- Specifically, as buildings are electrified, smart transition pathways are needed to reduce cost burden on the remaining ratepayers.

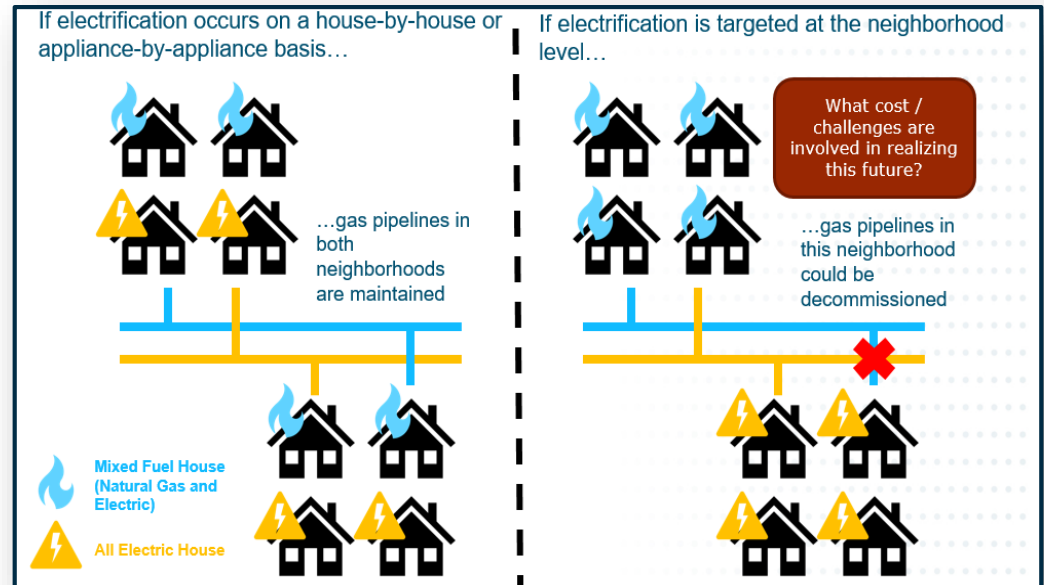
*\*CPUC Lead Commission on adaptation (Randolph)*

# FY 2019-20 Proposed Funding Initiatives

## Natural Gas Infrastructure Analysis and Strategic Pathway to a Low-Carbon Energy

### Background:

- Electrification of individual buildings is problematic as it would require both upgrade of electrical infrastructure and maintenance of gas infrastructure, resulting in significant costs to ratepayers.
- Current work is exploring if electrifying whole areas at once would more effectively meet state goals while minimizing the cost burden on natural gas ratepayers. (PIR-16-011, E3)



Source: Energy+Environmental Economics (E3), Agreement no. PIR-16-011



# FY 2019-20 Proposed Funding Initiatives

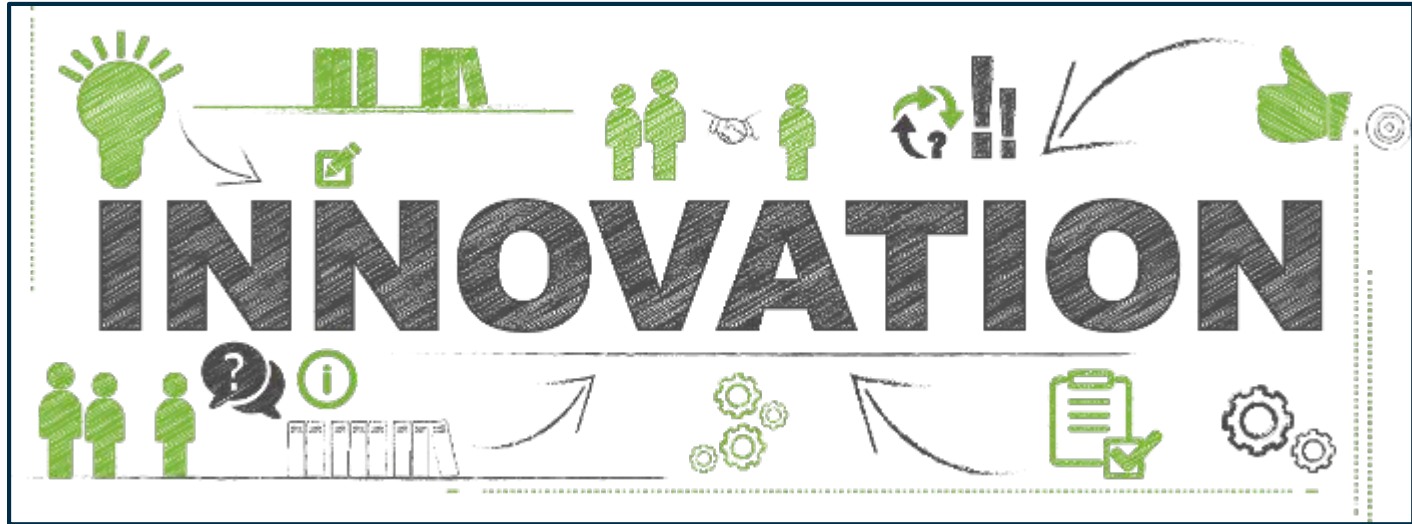
## Natural Gas Infrastructure Analysis and Strategic Pathway to a Low-Carbon Energy

### Research Description:

- This research initiative would explore a strategic approach to natural gas pipeline decommissioning.
- This funded entity is expected to:
  - Develop criteria (e.g. system age, use patterns, effect on infrastructure safety and reliability) to determine best geographical candidates for a pilot project.
  - Perform GHG reduction analysis and cost-benefit analysis comparing gas & electric to electric-only service including cost over time.
  - Assess customers most likely to be interested in such a pilot and identify what may persuade customers to relinquish gas service (e.g., alternative rate structures, rebates for electric appliances).
  - Collaborate with gas utilities to engage customers and execute the project.
  - Prioritize safety and benefits to ratepayers.
- The results of this study would develop methodology for decision makers to determine where natural gas infrastructure retreat is plausible, economically viable, and ratepayer-supported, and would lead to a pilot-project to implement this methodology.



# Small Grants for Early Stage Research

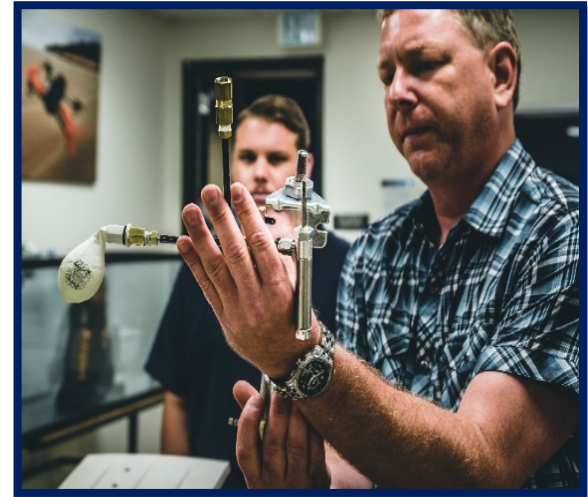


Presenter: Josh Croft

# Background

## Entrepreneurs with Early Stage Energy Technologies Face Unique Challenges

- Lack of early seed funding to prove concept feasibility
- Little understanding of the business and legal aspects needed to successfully commercialize their invention





# Current and Past Efforts

## **PIER Electric and Natural Gas Small Grants Program**

- Energy Innovations Small Grant (EISG) Program – started in 1998
- Provided grants of \$75k to \$150k
- Over 450 small grants awarded – over \$1.5 billion in follow-on funding
- Active for almost two decades

## **Electric Program Investment Charge – Electric Small Grants Program**

California Sustainable Energy Entrepreneur Development (CalSEED) Initiative – started in 2016

- \$150k small grants and technical consulting, mentoring, and business resources
- Business Plan Competition for additional \$450k
- Consistently oversubscribed (700+ applications received; 46 awarded) and some early private follow-on investments and partnerships



# Low-Carbon Natural Gas Small Grants Program

## Research Description:

This initiative will provide seed-level funding to businesses, non-profit organizations, individuals, national laboratories, academic institutions, and other qualifying entities for research that establishes the feasibility of innovative new energy concepts that benefit natural gas ratepayers. As opposed to the other proposed initiatives in this FY 2019-20 Investment Plan that focus on the more mature stages of technology development, this initiative will address an important gap in the early technology development phase where small amounts of funding can have a significant effect.

## Estimated Ratepayer Benefits:

A small grants program for natural gas technologies would address a critical gap in the early technology development phase where small amounts of funding can have a significant impact in bringing new ratepayer-beneficial innovations to market by providing seed funding as well as mentoring, technical consulting, and business development services to support energy entrepreneurs and research teams in their quest to develop breakthrough clean energy solutions.



# Questions for the Stakeholders

## *Low-Carbon Natural Gas Small Grants Program*

- The Electric Program Investment Charge's small grant program for electricity technologies provides \$150k small grants along with business and technical expertise.
  - For early stage natural gas technologies (Technology Readiness Level 2-4) is that award amount appropriate?
  - Are there any additional resources entrepreneurs might need in order to develop natural gas technologies?
- What examples are there of early stage natural gas technologies and/or natural gas alternatives (i.e., solar thermal; renewable natural gas) that would benefit from a small grant to further the concept?

# Natural Gas-Related Transportation Research



Presenter: Peter Chen

# Goals

- Increase freight efficiency and competitiveness
- Reduce carbon emissions and increase the use of renewable transportation fuels
- Improve air quality
- Improve infrastructure capacity, reliability, and sustainability



# Current Portfolio

## Near-Zero Emission Natural Gas Engine Development

- Commercializing heavy-duty natural gas engines certified to CARB's optional low NOx standards that can be deployed with renewable natural gas

## Natural Gas Fueling Infrastructure Improvements

- Improving fast-fill CNG dispenser technology to increase storage tank utilization, vehicle range

## In-Use Emissions and Fuel Usage Study

- Conducting real-world tests to characterize natural gas vehicle in-use emissions and fuel usage

## Natural Gas Hybrid-Electric Vehicles

- Improving fuel efficiency and air quality benefits of natural gas vehicles by optimizing the integration of advanced hybrid-electric drivetrains

## Advanced Combustion Research

- Developing advanced ignition systems to extend the dilution tolerance of natural gas engines.
- Improving natural gas engine efficiency and maintaining near-zero emissions

## Heavy-Duty Off-Road Applications

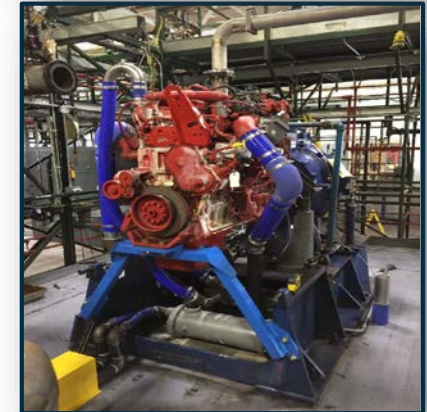
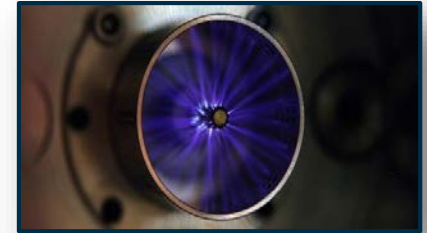
- Adapting low emission on-road natural gas engine technology to off-road vehicles



# Program Highlights

## Increasing Dilution Tolerance and Durability of Low NO<sub>x</sub> Engines (NG/RNG) using Transient Plasma Ignition

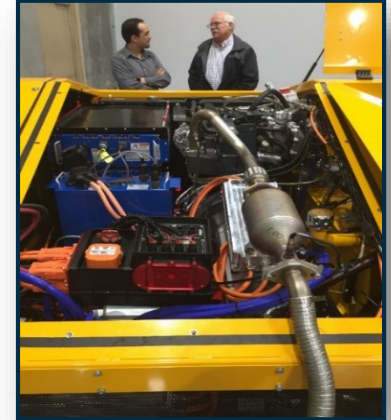
- **Recipient:** Transient Plasma Systems, Inc.
- **R&D Funds:** \$899,139
- **Goal:** Develop a low-energy plasma ignition system to improve spark ignition.
- **Technology and Accomplishments:**
  - Single cylinder tests have shown stability at high EGR rates of up to 33%, which can translate to reduced emissions and improved efficiency.
  - Developing a prototype for multi-cylinder testing at Argonne National Lab on a commercially available Cummins Westport ultra-low NO<sub>x</sub> engine.
- **Market Potential:** After demonstrating multi-cylinder capability, TPS plans on developing a production-intent design for on-road vehicles or stationary engines.
- **Benefits:** Improve competitiveness of ultra-low NO<sub>x</sub> engines compared to diesel engines. Efficiency improvements result in reduced GHG emissions (approx. 10% incrementally) and fuel consumption. Improved spark plug durability can extend maintenance intervals.



# Program Highlights

## Developing a CNG Hybrid Power System for Off-Road Vehicles

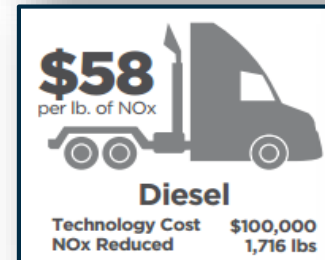
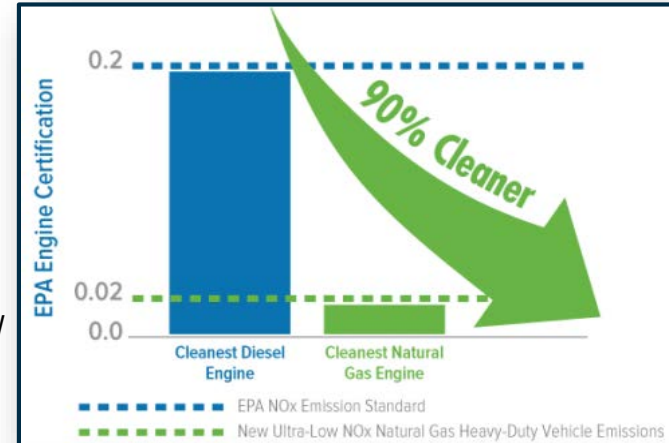
- **Recipient:** Terzo Power Systems, LLC.
- **R&D Funds:** \$1,497,400
- **Goal:** Develop and integrate a CNG hybrid-electric power system to power an off-road almond harvester in place of a conventional diesel engine.
- **Technology and Accomplishments:**
  - De-couple engine from hydraulics and propulsion with a series hybrid architecture to increase efficiency.
  - Potential for 50% reduced fuel consumption by eliminating intermittent operation.
  - Field demonstration will take place in Madera almond orchard over the 2019 harvest season.
- **Market Potential:**
  - Almonds are California's top agricultural export with production spanning the San Joaquin Valley.
  - Modular and scalable design has potential to expand hybrid technology to other off-road applications.
- **Benefits:** Introduce a cleaner, more energy efficient alternative for off-road vehicles. Improve air quality for agricultural communities. Hybrid electric technology allows for zero emission when idling and in all electric mode. Engine technology can operate on RNG for further GHG reductions.



# Program Highlights

## Commercializing Heavy-Duty Near-Zero NOx Emission Engines

- **Recipient:** South Coast Air Quality Management District
- **R&D Funds:** \$2,000,000 (9-liter) + \$1,000,000 (12-liter)
- **Goal:** Develop and certify natural gas engines to a 0.02 g/bhp-hr NOx level ahead of a mandatory standard.
- **Technology and Accomplishments:**
  - Combined an improved three-way catalyst after treatment, closed crankcase ventilation, and optimized controls to reduce NOx emissions by 90% and methane emissions by 70%.
  - Engines are commercially available for major vehicle OEMs.
- **Market Potential:** As of October 2018, about 715 near-zero emission engines have been deployed in California, resulting in estimated NOx reductions of 96 tons/yr. Incentive programs are accelerating deployment with RNG fueling requirements.
- **Benefits:** Cost effective pathway to reduce NOx and GHG emissions. Provides near-term economic incentive to capture methane from waste streams for transportation fuel.





# Evaluation of the Transportation Research Area

- Since FY2010-11, the Natural Gas R&D Program has maintained a \$24 million annual budget. The transportation research area has typically requested \$3-4 million per year.
- In the FY2018-19 budget plan, Energy Commission staff presented research topics that could be pursued if additional funds were made available to help address aggressive policy objectives such as EO B-32-15 (Sustainable Freight), B-55-18 (Carbon Neutrality), and SB 1383 (Reducing SLCPs).
- The transportation research area successfully fostered near-zero emission technology development for on-road heavy-duty vehicles using a strategic portfolio approach driven by roadmapping efforts, stakeholder engagement, emission standards, and clean energy policies.
- With additional funds, the transportation research area can expand the program scope to better target large off-road vehicles and zero-emission technologies.

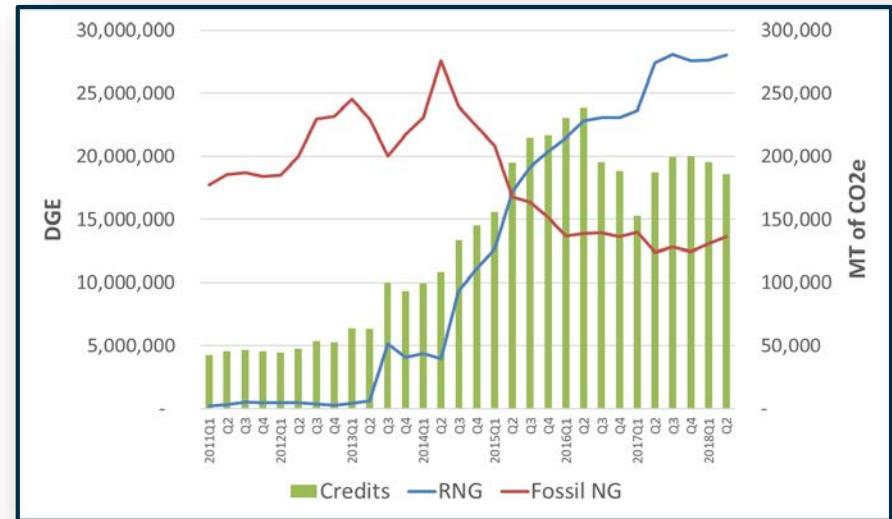
California's Growing Medium- and Heavy-Duty Natural Gas Vehicle Population

Year	2007	2015	2020	2030
Number of Natural Gas MHDVs	9,674	16,891	18,500	36,000-66,500
Transportation Natural Gas Consumption (DGE)	79M	142M	160M	210M-420M

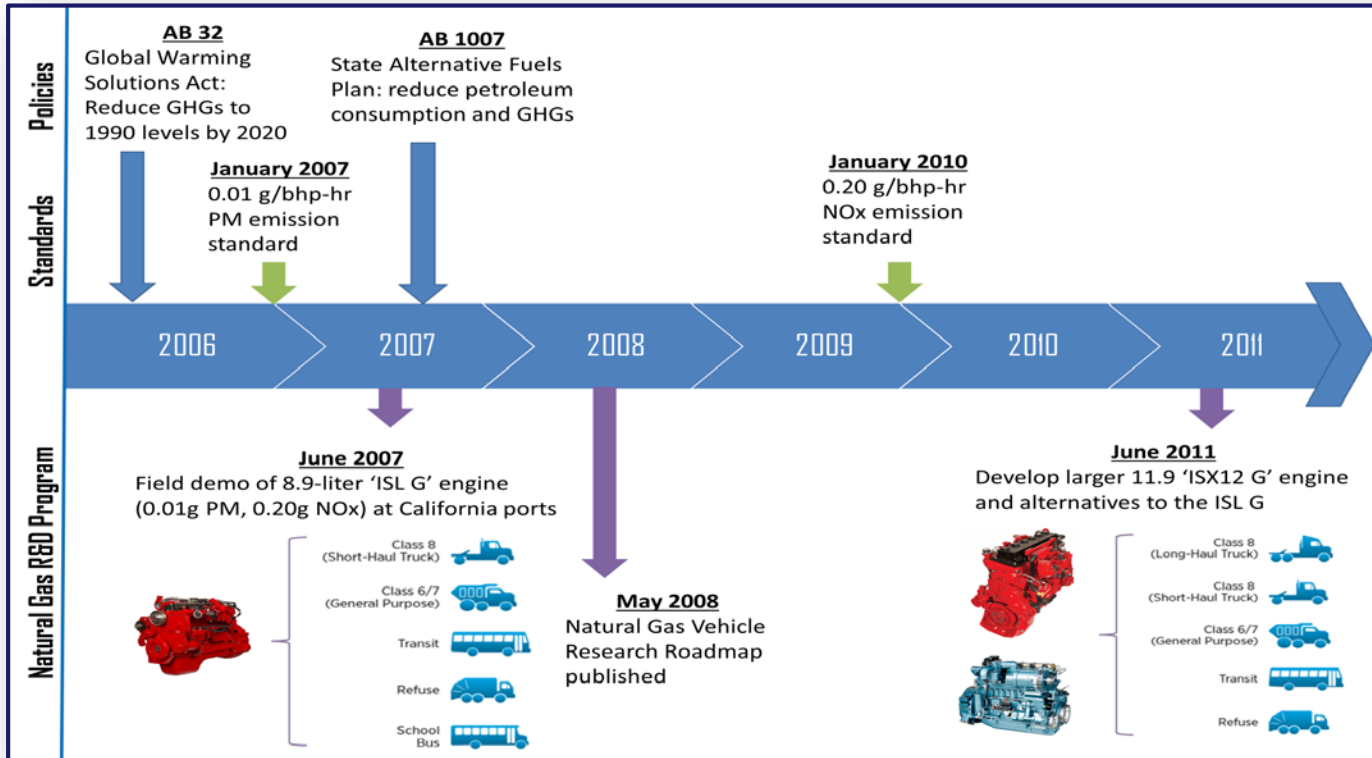
# Evaluation of the Transportation Research Area

- Studies estimate that California's economically viable renewable gas production potential to be 82 billion cubic feet, or 623 million DGE.
- LCFS and RFS incentivize RNG production and use as a transportation fuel by creating large revenue potential from the capture of methane from waste streams.
- 67% of natural gas reported in the LCFS is RNG. A growing natural gas vehicle population is critical to incentivize methane capture and reduce GHG emissions from the transportation sector.

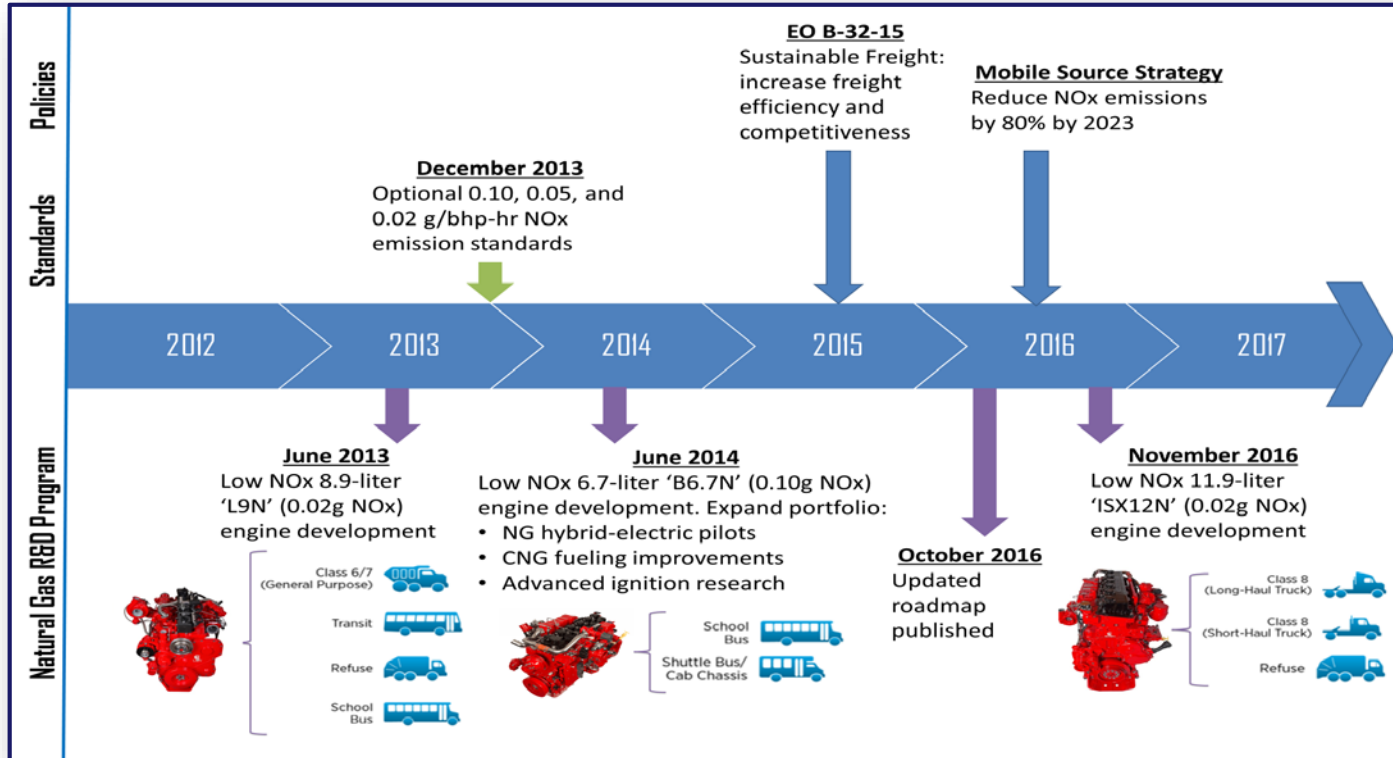
Volume of RNG and Fossil NG Reported in the LCFS



# 2006-2011: Policies and Standards Drive Interest in NGVs

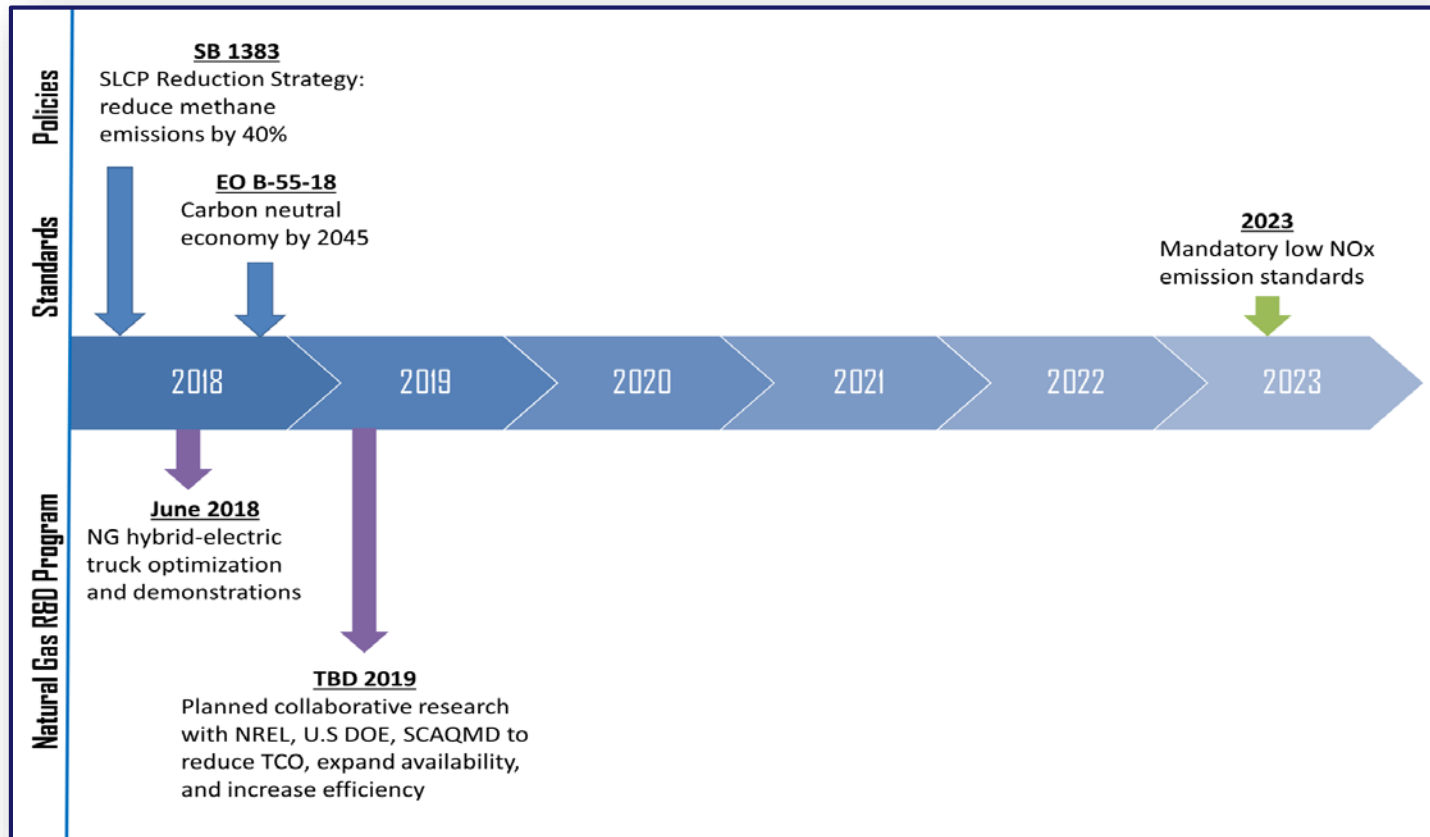


# 2012-2017: Near-Zero NOx Engines and Addressing Market Barriers





# 2018+: Next-Generation Technologies





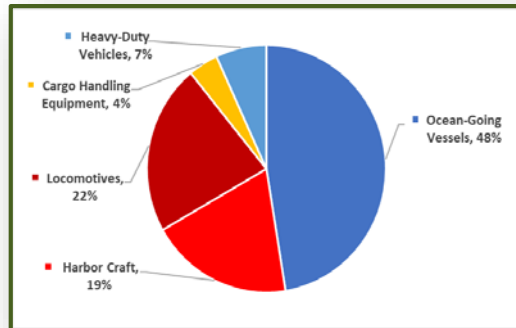
# FY 2019-20 Proposed Funding Initiatives

## Demonstrate Advanced Zero Emission Technologies in Rail and Marine Applications at California Ports

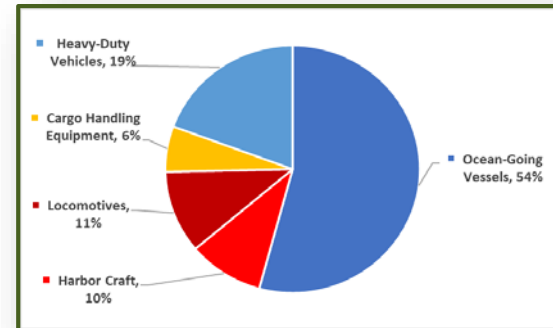
### Issue:

- Locomotives and harbor craft emit 41% of diesel particulate matter (DPM) and 21% of NOx emissions from goods movement related sources at the San Pedro Bay port complex.
- DPM is major near-source cancer risk to disadvantaged and low income communities surrounding California ports. NOx is a precursor to ozone and particulate matter and affects regional air quality.
- Locomotives and harbor craft typically use large diesel engines and require extended idling.

2017 San Pedro Bay Ports DPM Emissions (231.7 tons/yr)



2017 San Pedro Bay Ports NOx Emissions (13,490 tons/yr)





# FY 2019-20 Proposed Funding Initiatives

## Demonstrate Advanced Zero Emission Technologies in Rail and Marine Applications at California Ports

### Background:

- The Sustainable Freight Action Plan identifies opportunities to increase utilization of short haul rail and inland seaports to transport freight more efficiently.
- R&D focused on advancing alternatives to diesel engines for large off-road vehicles like locomotives and harbor craft is currently limited.
- Fuel cell technologies have higher efficiency than diesel engines and produce zero NOx, PM, and GHG emissions at the exhaust. They can effectively supplement battery storage and mitigate operational challenges such as long charging times.
- Unique deployment challenges include the long useful life of diesel engines, wide range of engine sizes and duty cycles, weight and space constraints, and lack of alternative fueling infrastructure.
- In-service demonstrations are critical to validate the technology's interoperability, economic feasibility, and potential for wider adoption.



# FY 2019-20 Proposed Funding Initiatives

## Demonstrate Advanced Zero Emission Technologies in Rail and Marine Applications at California Ports

### Research Description:

- Design, build, and demonstrate zero-emission locomotives or harbor craft that can successfully use zero-emission fuel cell technologies at California ports.
- Proposed architectures must demonstrate the ability to meet performance demands, vehicle design constraints, durability expectations, interoperability, maintainability, and safety requirements.
- Conduct R&D to evaluate and identify fuel cell architectures that would best address these limitations.

**Potential Partners:** Partners may include ports, fleets, railroad operators, research institutions, national labs, technology manufacturers and providers, and other governmental agencies.

### Estimated Ratepayer Benefits:

- Reduce NOx emissions affecting ambient air quality.
- Reduce DPM and noise affecting disadvantaged and low income communities that surround California's ports.
- Reduce GHG emissions by displacing diesel and securing long term demand for renewable gas.
- Use of gaseous fuels instead of diesel to power harbor craft can reduce risk of oil spills from vessels.



# FY 2019-20 Proposed Funding Initiatives

## Evaluate Viability, Potential Pathways, and Benefits of using LNG to Fuel Locomotives in California

### Issue:

- Although some intrastate locomotives may be able to adopt zero-emission technologies, operating specifications necessitate near-zero emission alternatives such as LNG to displace diesel consumption.
- Locomotives consume 260 million gallons of diesel annually in California. Interstate line haul locomotives can consume 300,000 gallons of diesel annually. Regional freight and commuter locomotives can consume 100,000 gallons of diesel annually.
- Near-zero emission natural gas engines are commercially available for on-road heavy-duty vehicles, but none are available that can exceed Tier 4 locomotive emission standards.

### Background:

- In October 2017, the Energy Commission published a feasibility study conducted by Gladstein, Neandross and Associates to evaluate the potential expanded use of LNG at seaports, particularly in high horsepower applications.
- A detailed study is needed to evaluate LNG technology and whether it can play a larger role in reducing pollutant and GHG emissions from locomotives in California.



# FY 2019-20 Proposed Funding Initiatives

## Evaluate Viability, Potential Pathways, and Benefits of using LNG to Fuel Locomotives in California

### Research Description:

- Conduct a study to evaluate where LNG may be feasible and most beneficial as an alternative locomotive fuel to diesel.
- Identify technology barriers in achieving near-zero emissions (beyond Tier 4) and potential research pathways for addressing them.
- Evaluate potential deployment strategies and costs related to LNG adoption.

**Potential Partners:** Partners may include research institutions, national labs, railroads, technology manufacturers and providers, and other governmental agencies.

### Estimated Ratepayer Benefits:

- Reduce diesel consumption from locomotives to achieve GHG emission reductions.
- Reduce NOx and DPM emissions from locomotives using cleaner LNG engines.



# Questions for the Stakeholders

## *Natural Gas-Related Transportation*

- Are we prioritizing the right initiative to expand the scope of the transportation research area beyond heavy-duty on-road vehicles?
- What barriers need to be overcome for the off-road sector to transition away from diesel to low carbon, low emission alternatives?
- How well does this initiative address needs to de-carbonize the transportation sector and reduce health impacts to disadvantaged and low income communities?
- What other research is needed to address California's need for aggressive emission reductions from the transportation sector?
- Are there opportunities for partnerships, collaborations, or synergies to leverage additional funding?

# Building End Use Energy Efficiency



Presenter: Mikhail Haramati



# Goals

With funding from the EPIC and the Natural Gas R&D programs, the Energy Efficiency Research Office's Building Efficiency Group conducts research to reduce the energy use of new and existing buildings through:

- Increase energy efficiency
- Reduce operating costs of building end-uses
- Reduce energy use and greenhouse gas emissions
- Commercialize new technologies with potential for broad market adoption





# Current Portfolio

## Advancing Solar Water Heating

- Demonstrate aluminum and copper mini-channel solar water heating technology to lower cost for the residential, commercial and industrial facilities.
- Demonstrate natural gas hot water heat pump paired with a solar thermal evacuated tube collector and hot water controls in multifamily buildings.
- Evaluate costs and benefits of community versus individual solar water heating

## Water Heating

- Demonstrate natural gas heat pumps for integrated hot water and air conditioning in restaurants
- Demonstrate residential gas heat pump water heaters

## Heating, Ventilating and Air Conditioning (HVAC)

- Demonstrate advanced high efficiency, low capacity HVAC systems
- Demonstrate an efficient, advanced air-distribution approach to reduce energy use in hospitals using real-time indoor air quality sensors, advanced fault detection and diagnostic software, and monitoring-based commissioning.

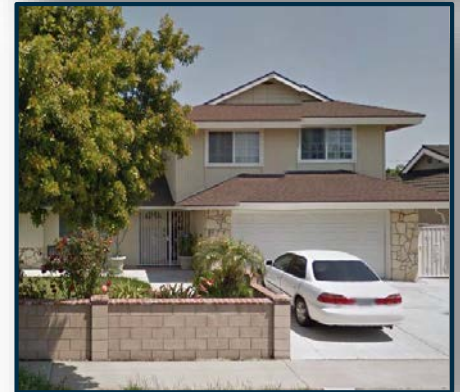
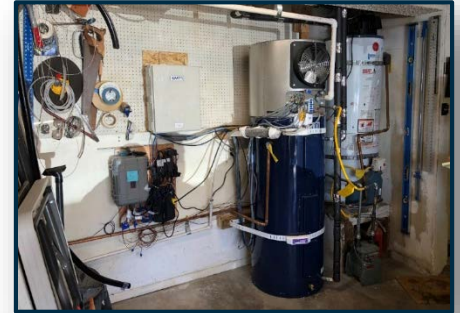
## Other

- Evaluate implications of using renewable natural gas appliances
- Understand occupant natural gas use in low-income multifamily communities.

# Program Highlights

## Gas Heat Pump Water Heaters for Homes

- **Recipient:** Gas Technology Institute
- **R&D Funds:** \$1,084,230 (Match \$310,500)
- **Goal:** 50% annual reduction in natural gas use for domestic water heaters
- **Technology:**
  - Integrates a small, gas-fired, single-effect, absorption heat pump with a hot water storage tank in 5 homes in LA area
  - Use existing water heater gas piping and venting
  - Lower first cost and operating cost than electric heat pump systems
  - Potential GHG savings of 50% when compared to baseline gas storage water heaters
- **Accomplishments and Market Potential:**
  - Installation complete and units now operating with local air district approval
  - Market Potential: Existing homes that would require an electrical service upgrade for an electric heat pump
- **Next Steps:**
  - Monitoring and data collection



# Program Highlights

## Gas Heat Pumps to Provide Hot Water and Supplemental Air-conditioning for Restaurants

- **Recipient:** Gas Technology Institute
- **R&D Funds:** \$864,294 (Match \$265,000)
- **Goal:** 40% reduction in annual natural gas use for hot water and at least 20% reduction in annual air conditioning cost.
- **Technology:**
  - Low-cost, gas-fired heat pump system for commercial restaurants
  - Produces: hot water and air conditioning
  - Unlike electric heat pumps, no electrical upgrade is needed, reducing overall project costs
- **Accomplishments and Market Potential:**
  - Baseline monitoring complete.
- **Next Steps:**
  - Installation at two full service restaurants is scheduled for early 2019



# Program Highlights

## Demonstration of High-Efficiency Commercial Cooking Equipment and Kitchen Ventilation System

- **Recipient:** Frontier Energy
- **R&D Funds:** \$1,061,800 (Match \$12,000)
- **Goal:** Reduce on-site energy consumption in commercial kitchens
- **Technology:** Demonstrate and characterize the energy savings potential, cost effectiveness, and cooking performance of high efficiency equipment
- **Accomplishments and Market Potential:**
  - Demonstrations at 6 food service test sites
  - 20%-60% reduction in cookline energy use at each site
  - Up to 76% water savings on new steamers and combi ovens
  - Ventilation savings over 50%.
- **Next Steps:**
  - Publish final report
  - Disseminate results to food service operators and professionals and recommend to utility rebate programs





# FY 2019-20 Proposed Funding Initiatives

## Innovative Solutions for Facades and Envelopes

### Background:

- Tighter building envelopes allow for reduced heating and cooling costs, improved comfort, and reduced infiltration of outside air.
- Most of the existing homes in California built more than 30 years ago lack wall insulation.
- 25% of the heating energy for homes and 30% of the heating for commercial buildings is lost through leaky windows in cold weather.
- For buildings with natural gas heating, envelope improvement can significantly reduce natural gas use, customer bills, and greenhouse gas emissions.
- New materials are being developed to increase the strength, use, efficiency, fire-resistance, and resiliency of facades. These include sealants, 3D printed designs, custom manufacturing, and new panel and window systems.
- Retrofit solutions -- including recladding, fenestration replacement, and sealing – are potential applications for these new materials.
- Envelope measures save energy in the building regardless of fuel type – making it well aligned with fuel switching goals



# FY 2019-20 Proposed Funding Initiatives

## Innovative Solutions for Facades and Envelopes

### Research Description

- Façade Retrofits with Manufactured Solutions:
  - Develop and demonstrate cost-effective, retrofit approaches for integrated envelope solutions
  - Market: Retrofits for existing residential and commercial buildings.
  - Minimally disruptive, aesthetically pleasing, quick to install, cost-effective
  - Packages are:
    - Integrated envelope solutions with innovative, existing technologies such as: triple pane windows, advanced insulation, sealants, cool paint, and fire resistance
    - Manufactured/preassembled off-site, utilizing an approach for quick installation at the building location



# FY 2019-20 Proposed Funding Initiatives

## Innovative Solutions for Facades and Envelopes

- **3D Printed Facades:**
  - Develop and test: new and emerging materials for 3D printed façades with insulating properties.
  - Market: New construction, commercial buildings.
  - Example materials may include carbon fiber printing in place of structural steel, fire-retardant, and low GWP technologies. Areas to be researched include: structural strength, R value, cost, GHG emission reductions compared to conventional.
- **Individual Envelope Measures:**
  - Test and demonstrate individual new technologies to improve the building envelope.
  - Market: All buildings, new construction and retrofit.
  - Includes lab testing and/or demonstrations
  - Technologies may include: windows, insulation, window coverings, sealants, and other individual measures



# FY 2019-20 Proposed Funding Initiatives

## Innovative Solutions for Facades and Envelopes

### Potential Partners and Customers:

- Partners: Builders, designers, architects, advanced manufacturing firms, envelope component manufacturers, software developers, research organizations, project financiers, local permitting offices, affordable housing organizations, California Air Resources Board and other public agencies interested in health impacts of envelope materials
- Customers: Commercial and residential building owners and operators (including multi-family)

### Estimated Ratepayer Benefits:

- Reduced statewide consumption of natural gas and associated greenhouse gas emissions.
- Increased affordability and thermal comfort of residential and commercial properties
- Reduced operating costs for ratepayers in selected properties
- Increased fire resiliency for retrofitted properties
- Aligned with fuel switching goals





# Questions for the Stakeholders

## *Building End Use Energy Efficiency*

- **Integrated, Manufactured Façade Solutions**
  - Should we require the integrated solutions to be manufactured off-site – or should we be flexible? I.e. integrated solutions and manufactured facades?
  - Should we fund these as pilots in actual buildings? If so, what would the permitting issues be?
  - What building types in CA climate zones would be good candidates for integrated façade retrofits?
  - What should the cost targets be for manufactured façade solutions?
- **3D Printed Facades**
  - Is this of interest to the building and design community?
  - What are potential barriers?
  - Are there technologies that are insulating, strong, and 3D printed that can be tested now in new buildings?
  - Or do new materials need to be developed to meet this criteria?
- **Individual Envelope Measures**
  - What other envelope measures should we include?

# Industrial End Use Energy Efficiency



Presenter: Colin Corby

# Goals

## Conduct R&D to help the industrial sector:

- Increase energy efficiency
- Reduce operating costs
- Increase the industry's competitiveness in the global economy while reducing greenhouse gas emissions
- Develop measures to meet environmental challenges while maintaining or enhancing energy efficiency including:
  - Maintain or increase productivity while reducing emissions (e.g., low NOx)
- Advance, demonstrate and commercialize emerging and new technologies with broad market potential



# Current Portfolio

## Increase Efficiency and Reduce GHG Emissions from Natural Gas Using Facilities

Develop and demonstrate emerging energy saving technologies that can directly reduce natural gas use and greenhouse gases and other emissions.

### Examples of current projects:

- Demonstrate low temperature, heat recovery for the chemical industry using low cost sulfur as a phase change material and eliminating costly pressure vessels and compressors.
- Demonstrate smart combustion technology using natural gas fuel quality sensors to predict fuel quality and adjust burners to optimize combustion.
- Develop a technical assessment report to identify research needed to help the chemical and allied products industry reduce natural gas use.
- Demonstrate an advanced rotary drum dryer coupled with a heat pump to reduce natural gas used for drying of bulk foods.
- Demonstrate an advanced low NOx combustion systems for industrial bakeries that reduces process temperature, NOx emissions while increasing energy efficiency.

# Program Highlights

## Conversion of Low Value Waste Heat into High Value Energy Savings

- **Recipient:** Gallo Cattle Company
- **R&D Funds:** \$1,207,136 (Match \$402,379)
- **Goal:** Use low value waste heat for industrial chilling, boiler, cleaning and water pre-heating with the goal of reduce site natural gas use by 23% and electricity use by 38%
- **Technology:** Develop and demonstrate a multi-stage heat recovery system that can take waste heat from biogas generators and economizers to run a ammonia-based absorption chiller.
- **Accomplishments and Market Potential:**
  - Project shows annual savings of \$475,000 and 1,142 metric tons of CO<sub>2</sub>e reduction
  - Simple payback of 3.4 years based on energy savings
  - Waste heat utilization is transferable to facilities producing refrigerated food
- **Next Steps:**
  - Final report under review and to be published spring 2019
  - Successful demonstration could pave the way for others to use this technology to recover waste heat for chilling and hot water needs to reduce energy and costs – especially dairy farms with refrigeration needs.



# Program Highlights

## Demonstration of a Novel Ultra-Low Oxides of Nitrogen Boiler for Commercial Buildings

- **Recipient:** Gas Technology Institute (GTI)
- **R&D Funds:** \$798,788 (Match \$525,000)
- **Goal:** Reduce natural gas consumption, operating cost and greenhouse gas emissions while maintaining compliance with local air district requirements
- **Technology:** dynamic stage entrainment (DSE) ultra-low-NOx burner for commercial steam distribution system
- **Accomplishments and Market Potential:**
  - Documented a 9% savings in fuel usage as compared to the baseline boiler
  - The DSE burner technology satisfied all of the performance targets--demonstrating the ability to achieve <9 vppm NOx emissions
  - Technology demonstrated ability to achieve low NOx emissions while increasing cost-competitiveness and is applicable to industrial boilers which account for about 40 percent of natural gas consumed in California
  - DSE technology can apply to about 10% of boilers in California (approximately 2,000 boilers) or the equivalent of 40,625 boiler horsepower within 10 years of commercialization.
- **Next Steps:**
  - Final report to be published spring 2019
  - GTI has partnered with Power Flame Inc., a leading manufacturer in the United States of burners for commercial and industrial applications, to bring the technology to market





# FY 2019-20 Proposed Funding Initiatives

## Developing and Demonstrating Advanced Combustion Systems

### Issue:

- Combustion air is typically 80% nitrogen and 20% oxygen
  - substantial share of energy is used to heat nitrogen resulting in energy losses of up to 70 percent
  - typical concentration of carbon dioxide in flue gas is about 5 percent, which hinders CO<sub>2</sub> capture, as equipment has to be oversized to process the nitrogen

### Background:

- California industries account for approximately 36% of total natural gas use (2016) and also annually generate approximately 23% of the greenhouse gas emissions making them a prime target for innovative technologies to reduce natural gas and greenhouse gas emissions
- 85% of industrial natural gas is used for process heating



# FY 2019-20 Proposed Funding Initiatives

## Developing and Demonstrating Advanced Combustion Systems

### Research Description:

- Develop and demonstrate economically viable advanced combustion systems for industrial facilities in California, that increase efficiency and reduce GHG emissions. Apply and expand on the results of past research on promising technologies that have been shown to be successful on large scale (e.g., powerplants) but not at the industrial plant scale. The goal is to improve efficiency and reduce costs and greenhouse gas emissions for industrial plants.

### Potential Technologies:

- chemical looping combustion
- oxy-fuel combustion
- extraction of oxygen using cryogenic, pressure/temperature swing adsorption, membranes, etc.
- utilization of waste energy sources (including absorption chillers, thermoelectric elements, etc.) and by-products (e.g. use of cryogenically extracted nitrogen for food conservation, refrigeration, separation of gases and liquids)
- direct (retrofitted or new equipment) or indirect heating (including infrared heating)





# FY 2019-20 Proposed Funding Initiatives

## Developing and Demonstrating Advanced Combustion Systems

### Industries Targeted:

- Food processing, glass, cement, chemical manufacturing, oil and gas extraction and refineries, pharmaceutical, and metal melting and processing

### Potential Partners and Customers:

- Industry, utilities, major equipment manufacturers, public/private research organizations and governmental agencies

### Estimated Ratepayer Benefits:

- Reduce energy use and costs, reduce greenhouse gas and other air emissions, potential to assist industries to be economically competitive in California



# Questions for the Stakeholders

## *Industrial, Agriculture and Water Efficiency*

- California's industrial sector uses 36% of the state's natural gas primarily for process heating. Our proposed initiative focuses on improvements to the combustion process.
  - We've identified a number of technologies, are there others we should consider? Which ones should be the highest priority in the near term and long term (e.g., by 2050)?
  - Should the research focus on incremental improvements or transformative, disruptive technologies?
  - What criteria are most important to industries when evaluating technology?
- What specific energy efficiency research gaps and technologies should be targeted to help California industries be competitive? Especially to reach our 2050 goals (80% below 1990 CO2 levels by 2050)?
- The CPUC has emphasized in resolution G-3519 that R&D funds should target industries and facilities that are emissions intensive and covered under the California Air Resources Board's Cap and Trade program.
  - What recommendations for effectively bringing *large* natural gas industrial users into the R&D program?
  - Would fewer, yet larger awards (e.g. \$3-6 million) increase program participation?

# Renewable Energy and Advanced Generation



Presenter: Chuck Gentry

# Goals

With funding under the EPIC and the Natural Gas R&D programs, the Renewable Energy and Advanced Generation program area conducts research that reduces barriers and increases penetration of renewable energy.

Under the natural gas research program, our goal is to reduce dependence on fossil-derived natural gas by:

- Advancing the development and market availability of clean and efficient distributed generation (DG) and renewable combined heating, cooling and power technologies
- Developing hybrid, fuel-flexible, energy efficient, and low emission DG technologies for natural gas and renewable alternatives
- Accelerating decarbonization by developing and demonstrating technologies for the conversion, cleanup, and upgrading of biogas to renewable gas



# Current Portfolio

## **Advancing Clean Energy through Biogas, Biomethane, and Natural Gas**

- Innovative technologies and strategies for converting biomass resources to biogas and for cleaning and upgrading biogas to renewable gas.

## **Novel Solutions to Accelerate Deployment of Small and Micro-Scale Combined Cooling Heating and Power (CCHP) Systems**

- Enabling technologies including thermal energy storage and thermally-driven cooling to expand the applicability of CCHP systems.

## **Improving Waste Heat to Power and Near-Zero Emission DG Systems**

- Innovative technologies for converting industrial waste heat to electricity, and DG systems which can achieve near-zero criteria pollutant emissions (focus on NOx) while maintaining high efficiency.

## **Innovative solutions to convert California's residual forest biomass resources into renewable gas**

- New technologies which can cost-effectively convert California's abundant forest waste biomass into renewable gas.

## **Improved Functionality and Readiness of Advanced Distributed Generators for Fire Risk Regions and Critical Facilities and Central Valley Agricultural Waste Resources to Energy**

- Innovative technologies and strategies to address barriers to deploying distributed generation in high fire risk regions, to support critical facilities.

# Program Highlights

## A Comprehensive Assessment of Small Combined Heat and Power Technical and Market Potential in California

- **Recipient:** ICF Incorporated
- **R&D Funds:** \$200,000 (Match \$20,000)
- **Goal:** Perform a comprehensive assessment of small and micro-scale combined heat and power technical and market potential in California.
- **Market Potential:**
  - 11.6 GW of technical potential for CHP <5 MW
  - 5.7 GW of economic potential (<10 year payback)
  - 1.9 GW of expected market adoption through 2037 (does not include emerging micro-CHP options for single family homes)
- **Conclusions:**
  - Strong potential for small CHP applications in California
  - Over 80 percent of capacity for economic potential and adoption comes from traditional CHP applications (50 kW to 5 MW)
  - If standby rates and departing load charges were removed, CHP economics improve and adoption would increase nearly 40%

CHP Market	Total Capacity (GW)		
	Technical Potential	Economic Potential	Market Adoption
Traditional CHP (50 kW – 5 MW)	7.4	4.6	1.6
Micro-CHP (10-50 kW)	2.5	1.1	0.3
Single Family Home Micro-CHP (1-2 kW)	1.7	n/a	n/a
<b>Total (&lt;5 MW)</b>	<b>11.6</b>	<b>5.7</b>	<b>1.9</b>

*Summary of California CHP Market Assessment*

# Program Highlights

## A Novel Low-Cost, High-Efficiency Solar Powered Micro-CHP System for Electricity, Hot Water, and Space Heating

- **Recipient:** UC Merced
- **R&D Funds:** \$816,659 (Match \$118,472)
- **Goal:** Develop a novel, low-cost, high-efficiency solar combined heat and power (CHP) system capable of producing electricity for building loads and heat for hot water and space heating.
- **Technology:**
  - Non-imaging optics for solar concentration
  - Aluminum mini-channels for thermal collection
  - Commercially-available solar cells for electricity production
  - Packaged in a glass tube
- **Benefits:**
  - Combined system has smaller footprint and a lower cost than two separate systems would have
  - Estimated payback period of about 4 years

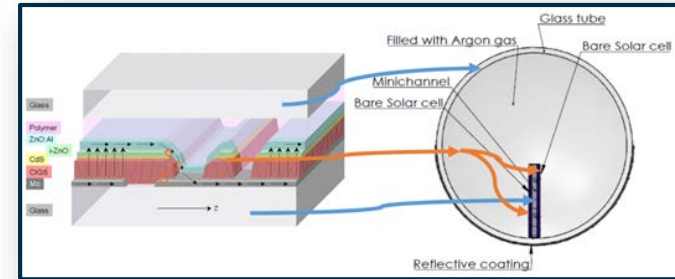


Diagram of the channel system that will collect thermal energy

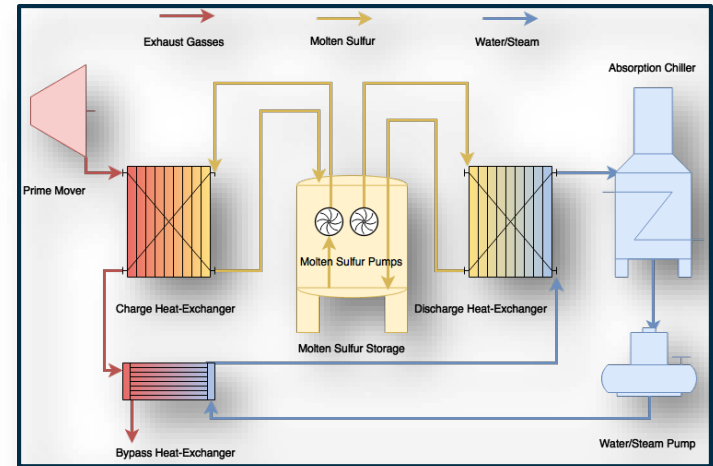


10-tube (5 flow through on left, 5 heat pipe on right) prototype array undergoing performance testing at the University of California, Merced – Castle Research Center.

# Program Highlights

## CCHP Packaged System with Innovative Sulfur-based Thermal Energy Storage

- **Recipient:** Element 16 Technologies
- **R&D Funds:** \$1,500,000 (Match \$150,000)
- **Goal:** Develop and demonstrate a low-cost, highly flexible sulfur-based thermal energy storage (SuTES) technology for integration with CCHP.
- **Technology:**
  - Molten sulfur heat storage
  - Stable at high temperatures
  - Good heat transfer properties
  - Single tank design
- **Benefits:**
  - Low cost storage media (\$65/ton)
  - Compact footprint
  - Flexible



*Photo of the CCHP System with SuTES*



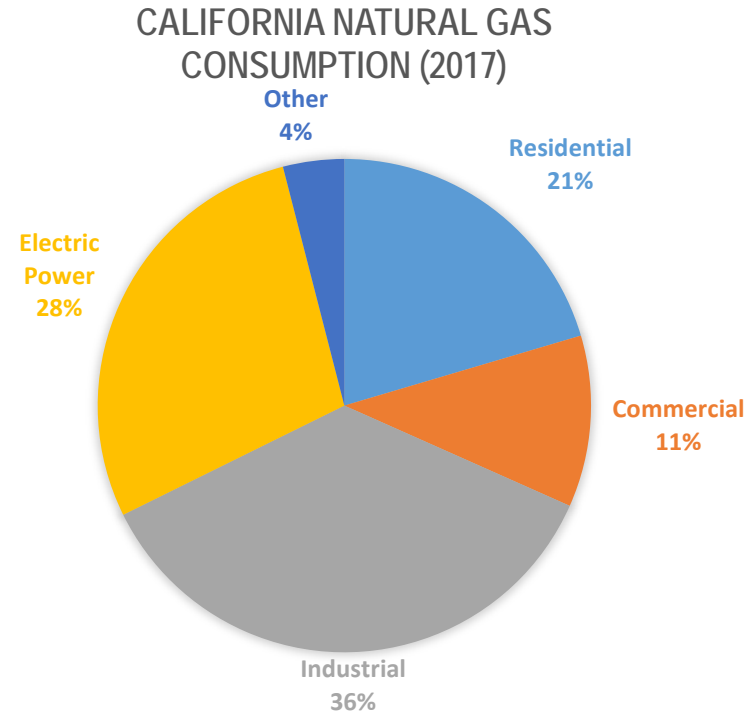


# FY 2019-20 Proposed Funding Initiatives

## Solar Heating, Cooling, and Power for Industrial Applications

### Issue:

- In California, the industrial sector is the leading consumer of natural gas at about 36% of the total natural gas consumption.
- Industry also generates approximately 23% of the States greenhouse gas emissions.
- Consequently, there is a good opportunity within industry for reduction of natural gas use and greenhouse gas emissions.





# FY 2019-20 Proposed Funding Initiatives

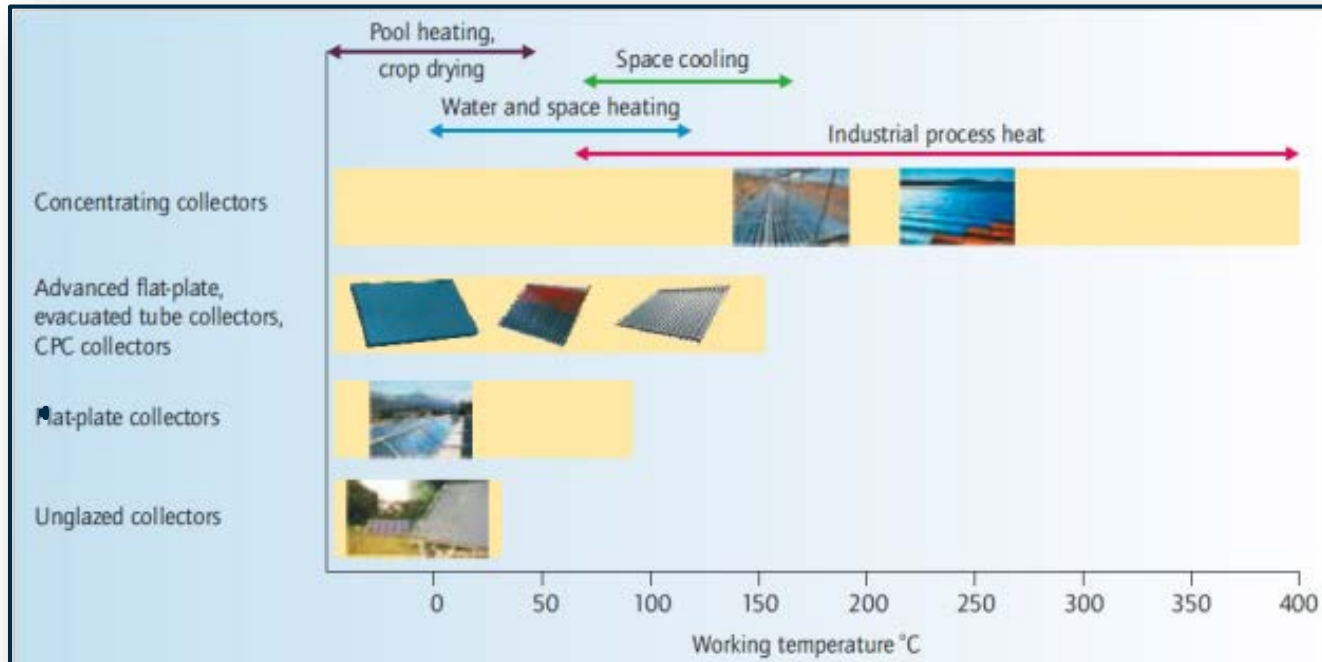
## Solar Heating, Cooling, and Power for Industrial Applications

### Background:

- In the manufacturing industry, 85% of the natural gas is used for process heat and indirect boiler.
- There is significant potential to meet much of this demand for heat with solar thermal technologies. However, there is a need to develop emerging solar thermal technologies for medium to high temperature that are more cost-effective.
- Challenges of solar thermal include cost-effectiveness and convenience of use.
  - Natural Gas equipment is relatively cheap
  - Natural Gas equipment is relatively more compact and convenient to operate
- Commercially available solar thermal systems, with tax credit and depreciation write offs, tend to have simple paybacks of about 5-10 years.
- To improve market adoption, payback needs to drop below 5 years.

# FY 2019-20 Proposed Funding Initiatives

## Solar Heating, Cooling, and Power for Industrial Applications





# FY 2019-20 Proposed Funding Initiatives

## Solar Heating, Cooling, and Power for Industrial Applications

### Research Description:

- Research will support technological advances to facilitate the adoption of solar heating, cooling, and power for industrial applications.
- Projects will advance the state of the art that will lead to cost-effective deployment of solar thermal systems, which could be a combination of solar thermal heating, heat driven cooling technologies, heat to power technologies, or hybrid systems, for industrial applications.
- Projects are expected to leverage advancement in medium to high temperature (e.g. greater than 125°C) solar thermal collection systems, typically based on solar concentrating systems and evacuated tubes, and develop integration approaches that lower the system cost and expand its application in the industry.



# FY 2019-20 Proposed Funding Initiatives

## Solar Heating, Cooling, and Power for Industrial Applications

### Research Description:

- Possible technologies and strategies include, but are not limited to, the following:
  - Improvement in thermal medium and heat exchange approaches to achieve high process temperature and increase system efficiency.
  - Develop and demonstrate integrated industrial solar thermal driven cooling or refrigeration system.
  - Develop and demonstrate an industrial solar thermal system that provides thermal energy for a heating process or subsequent cooling application and distributed power generation. Systems providing solar heat and power could integrate various technologies like organic Rankine cycle, thermoelectric, or PV while maintaining or improving performance over comparable standalone thermal collectors.
  - Demonstrate integration and installation approaches that lowers the overall system cost over traditional linear concentrator on a per kW basis.



# FY 2019-20 Proposed Funding Initiatives

## Solar Heating, Cooling, and Power for Industrial Applications

### Potential Partners and Customers:

- Food, chemicals, and plastics industries, and other industrial facilities; technology manufacturers and providers, project developers, utilities, and local, state and federal agencies

### Estimated Ratepayer Benefits:

- Reduce statewide consumption of NG while providing reduced transmission and distribution losses, and reduced transmission congestion on the local electric grid.
- Allow facility owners to affordably meet their on-site thermal and electric needs.
- Provide energy and cost savings as a result of increased deployment of solar thermal technologies.



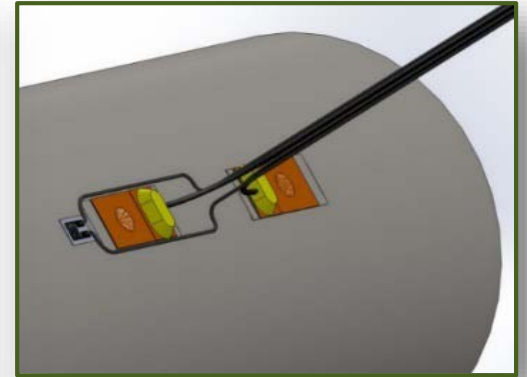
# Questions for the Stakeholders

## *Renewable Energy and Advanced Generation Research*

- Are there other solar thermal technologies or pathways we should consider funding?
- What are the non-technology barriers to deploying solar thermal systems at industrial sites?
  - (i.e. lack of available on-site expertise, financing, etc.)? How could we address these barriers?
- What advanced functionality for solar thermal systems would be most desired by facility owners?
- In what applications are solar thermal systems preferred over electricity and energy storage and vice versa?



# Natural Gas Infrastructure Safety & Integrity



Presenter: Yahui Yang



# Goals

- Conduct research in natural gas infrastructure (pipelines and storage) to increase public safety and system integrity and climate resiliency, enhance transmission and distribution capabilities of the natural gas system; and
- Address issues not adequately addressed by the regulatory and competitive markets





# Current Portfolio

## Areas of Ongoing or Recently Completed Projects

- High Accuracy Mapping for Pipeline Excavation Damage Prevention and Emergency Response
- GPS Excavation Encroachment Notification System
- Multi-analytic Risk Management for Pipeline and Underground Storage
- Pipeline Safety and Integrity Monitoring System and Technology Assessment
- Pipeline Right-of-Way Monitoring and Notification System

## Upcoming Project Areas

- Seismic Risk Assessment
- Improved Inspector Training

## New Areas Under Development

- Technologies for Infrastructure Damage Prevention
- Improving Automated Shutoff Equipment

# Program Highlights

## High Accuracy Mapping for Damage Prevention and Emergency Response

- **Recipient:** GTI
- **R&D Funds:** \$1,481,426
- **Goal:** Develop and demonstrate a system to accurately map subsurface pipelines and trace component features
- **Technology:**
  - Mobile GIS, high accuracy GPS
- **Accomplishments and Market Potential:**
  - Deployed and demonstrated 22 units at 10 PG&E service locations
  - Mapped nearly 40k ft of pipe and 3,475 point features
  - System able to map 90% of underground assets with average accuracy below 6 in
  - Target market is utility operators and mapping service providers
- **Benefits:**
  - Increase system resiliency and public safety by accurately locating assets
  - Efficient and low-cost compared with current paper records



# Program Highlights

## Quantitative Risk Management for Underground Gas Storage

- **Recipient:** DNV GL
- **R&D Funds:** \$2,398,939
- **Goal:** Demonstrate an advanced risk assessment methodology to identify, prioritize, and manage threats to underground gas storage
- **Technology:**
  - Bowtie model (hazard identification) and Bayesian network model (risk quantification)
- **Accomplishments:**
  - Identified hazards and safety barriers in collaboration with stakeholders
  - Developed both Bowtie model and Bayesian network model
  - Integrated Bowtie model into Bayesian network model
- **Next Steps**
  - Data collection from multiple sources and model validation
  - Model demonstration with utilities
- **Benefits**
  - Identify and prevent various hazards at early stage
  - Protect operators and the public; increase operation safety and system resiliency





# FY 2019-20 Proposed Funding Initiatives

## Advancing Technologies to Better Locate Depth of Subsurface Natural Gas Pipelines

### Issue:

- Information on buried pipeline depth is scarce, and has low levels of accuracy, reliability and confidence
- Existing data on pipeline depth may be out of date due to surface changes such as paving or landscaping
- Pipeline mapping technologies provide horizontal location information without vertical or depth data

### Background:

- Information on depth of subsurface pipelines is essential to locate assets and avoid damages from construction activities
- Digging or excavation to obtain pipe depth information is extremely costly and time-consuming
- Technologies of pipe detection from ground surface should be developed to obtain depth information in addition to horizontal location information
- Performance of pipe depth identification can be affected by broad range of factors, including pipe materials, availability of tracing wires, and properties of covering materials



# FY 2019-20 Proposed Funding Initiatives

## Advancing Technologies to Better Locate Depth of Subsurface Natural Gas Pipelines

### Research Description:

- Demonstrate technologies that are able to measure the depth of subsurface pipelines from ground surface, and validate the technologies on specific natural gas systems
- Apply the same or different technologies to depth identification of both plastic and metallic pipelines subject to various covering materials
- Integrate depth information to horizontal location data, and develop an interface to enter, process and visualize complete GIS data on handheld devices, such as a tablet
- Improve the accuracy and reliability of pipeline depth identification in a cost-effective way
- Address affecting factors in a real-world situation, and quantify the performance and limitations of specific technologies

### Potential Partners and Customers:

- Utilities, construction industry, agriculture industry

### Estimated Ratepayer Benefits:

- Help to maintain accurate and up-to-date records of underground asset depth information
- Beneficial to reduce or avoid pipeline damages resulted from excavation or digging activities
- Ability to quickly and accurately locate pipelines during or after emergencies



# Questions for the Stakeholders

## *Natural Gas Infrastructure Safety & Integrity*

- Are we addressing the most pressing issues? Are there other safety, resiliency or adaptation areas we should be addressing?
- Are there solutions that work for both plastic and metal pipes?
- What level of accuracy is desired for pipe locating?
- How to address data confidentiality of critical assets information?
- How can we leverage technologies from other industries to improve the natural gas infrastructure?

# Energy-Related Environmental Research



Presenter: Guido Franco



# Goals

- Develop cost-effective approaches to evaluating and resolving environmental effects of natural gas production, delivery, and use in California.
- Explore how new energy applications and products can solve/mitigate environmental problems.
- Identify vulnerabilities of the energy system to climate change and develop cost-effective approaches to ensure reliable energy services.



# Current Portfolio

## **Advancing characterization of methane emissions from California's natural gas system**

- The Energy Commission pioneered methane emissions research in California.
- Current and past projects investigate all sectors of the California natural gas system.
- Multi-tiered detection system deployed to identify emission sources.

## **Climate change vulnerability and adaptation research**

- Working with IOUs to identify vulnerabilities and adaptation options.
- Analyze natural gas energy scenarios vis a vis California's long-term energy and environmental goals.

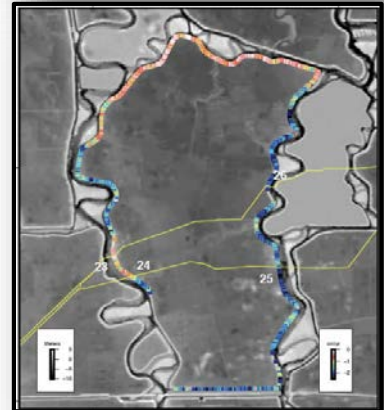
## **Air quality and public health impacts**

- Investigate indoor air quality and ventilation solutions.
- Air quality and public health implications of natural gas and renewable natural gas combustion.

# Program Highlights

## High Resolution Measurement of Levee Subsidence Related to Energy Infrastructure in the Sacramento-San Joaquin Delta

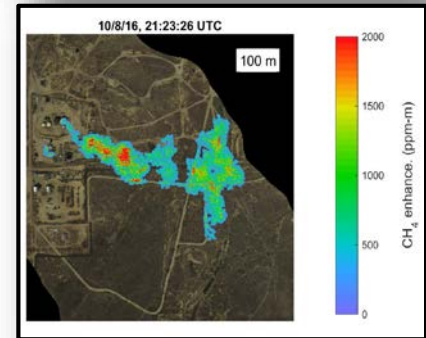
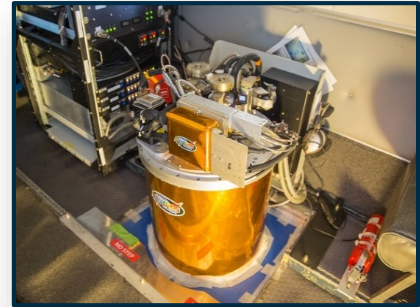
- **Recipient:** United States Geological Survey
- **R&D Funds:** \$325,000
- **Project Description:** Extensive, high-resolution field data was collected using LIDAR to determine levee subsidence rates and assess flood overtopping potential at Sacramento-San Joaquin Delta levees, with particular attention to areas of significance to the natural gas system. Researchers incorporated projected sea level rise into their analysis.
- **Highlights:**
  - Previous subsidence studies used satellites; this study corroborated previous findings that subsidence was occurring and increased the accuracy of results.
  - Subsidence rates can be on the order of centimeters/year.
  - Portions of levees will fall under federal standards between 2050 and 2080, endangering above ground portions of the natural gas system.
- **Ratepayer Benefits**
  - Researchers coordinated with utilities and stakeholders. This study provided information about the timing when PG&E may need to implement their adaptation strategy.



# Program Highlights

## Identification of Large Fugitive Methane Emitters from the Natural Gas Sector

- **Recipient:** National Aeronautics and Space Administration/Jet Propulsion Laboratory (NASA/JPL)
- **R&D Funds:** \$600,000 (Match: \$700,000, CARB; Leverage: \$900,000 NASA)
- **Project Description:** Deploying NASA's Airborne Visible InfraRed Imaging Spectrometer – Next Generation (AVIRIS-NG) in California to identify large fugitive methane emitters in the natural gas sector. CARB's portion of the project identified emissions outside the natural gas sector.
- **Highlights:**
  - Surveyed over 272,000 facilities and components. Estimated emissions from these sources is 0.607 Teragrams (Tg)  $\text{CH}_4$  per year, equivalent to about 35 - 43% of the State's methane inventory for 2016.
  - Super-emitter activity occurs in every surveyed sector.
  - Small number of sources produced the vast majority of emissions; the largest methane point source emitters in the State are 35 landfills.
  - About 25% of source emissions in California are due to the oil and gas supply chain; 80% of these oil and gas emissions are from production.
- **Benefits:**
  - Improves the accuracy of ARB's GHG Emissions Inventory.
  - Highlights the potential for efficient point source monitoring techniques to directly enable mitigation of super-emitters.
  - Estimated 0.151  $\text{TgCH}_4/\text{yr}$  in point source emissions for the oil and gas sector in California, representing approximately \$28-\$39 million in annual product loss at July 2018 US city-gate gas prices.





# FY 2019-20 Proposed Funding Initiatives

## Further Characterizing Methane Emissions and Development of Residential Sector Mitigation Methods for Methane Leakage

### Issue:

- Methane is a potent greenhouse gas and the dominant constituent of natural gas. It is roughly 25 times stronger at trapping heat compared to carbon dioxide.
- Identifying these leakage losses would provide benefits in the areas of safety, air quality and global climate. One potentially important subsector of natural gas infrastructure that may be the source of leakage is residential structures.
- There is little actual data on methane emissions from the residential sector. Current estimates of methane emissions from the residential sector may be underestimated, leaving a potential area for emissions reductions unaddressed.



# FY 2019-20 Proposed Funding Initiatives

## Further Characterizing Methane Emissions and Development of Residential Sector Mitigation Methods for Methane Leakage

### Background:

- A previous Energy Commission-funded study (500-13-008), based on measurements from about 70 single family homes in California, estimated total methane emissions from leakage in the residential sector are equivalent to about 0.5% of the state's total sector natural gas consumption, and equivalent to 15% of the total methane emission from the natural gas methane system. The Energy Commission was the first to quantify the scale of this leakage, and the results are being considered for incorporation into CARB's Greenhouse Gas Inventory.
- Additional field measurements from representative samples, particularly from multi-family housing, are necessary to increase the accuracy of the results and to determine what types of housing units are more prone to leak.
- Additionally, proper mitigation methods are needed to assist ratepayers in cost-effectively identifying and reducing the leakages.



# FY 2019-20 Proposed Funding Initiatives

## Further Characterizing Methane Emissions and Development of Residential Sector Mitigation Methods for Methane Leakage

- **Research Description:**
  - This research will conduct field measurements of methane emissions from a larger, more representative sample of California's residential sector; aiming for 100-200 units.
  - The additional measurements will include multi-family units that are often located in disadvantaged communities (DACs).
  - This research will also develop and implement methodologies that can cost-effectively identify and stop leaks in residential homes in California.
- **Potential Partners and Customers:** Natural Gas Utilities, CARB.
- **Estimated Ratepayer Benefits:**
  - The project will reduce fugitive methane emissions from ratepayers' homes participating in the study and directly provide energy cost savings.
  - The project will identify commonalities in high emitting homes, potentially enabling improved identification of good candidates for repairs or building electrification.
  - The project will identify cost-effective ways to reduce greenhouse gas emissions from California's residential sector and will also provide important information to the Air Resources Board to accurately account for greenhouse gas emission from the residential sector in California's official emission inventory.



# Questions for the Stakeholders

## *Energy-Related Environmental Research*

- What strategies might motivate participation of California residents in the study? What synergies might be leveraged to enhance the study? (e.g., collaboration with AB 617 efforts, insert in monthly bills)
- What collaboration with natural gas sector stakeholders (e.g., utilities, other state agencies, community-based organizations) might be helpful to ensure the study delivers useful results?
- Are we addressing the most important environmental issues that would affect the natural gas system in the next 5 to 10 years?
- Have we adequately identified a factor that may affect the natural gas industry in the next 30 years (from now to 2050)?





# Public Comments and Questions

- Please state your name and affiliation
- Please limit your comments to 3 minutes to allow time for others



# Closing Comments

Submit additional written questions/comments related to the FY 2019-20 Natural Gas R&D Budget Plan to:

**Nicole Dani**

[nicole.dani@energy.ca.gov](mailto:nicole.dani@energy.ca.gov)

**Deadline to submit written questions/comments:**

**Friday, February 1, 2019 - 5:00 PM PDT**

- Final draft to be submitted to the California Public Utilities Commission by March 31, 2019
- Copies of presentations and public comments from today's workshop will be posted at:  
<http://www.energy.ca.gov/research/>
- Copies of past budget documents can be found at:  
[http://www.energy.ca.gov/research/annual\\_reports.html](http://www.energy.ca.gov/research/annual_reports.html)